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POLARIZED LINE EMISSION FROM ELECTRON BEAM EXCITED HIGHLY CHARGED IONS

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The use of a beam to study electron-ion interactions introduces a symmetry axis and directionality in the collision system and results in the selected excitation of magnetic sublevels. Ions excited by unidirectional electrons, as a consequence, emit linearly polarized line radiation. Measuring the degree of polarization provides information about the collision processes and about the relative population density of individual magnetic sublevels.

We have performed measurements of the linear polarization of the x-ray lines emitted from beam-excited ions.[1–3] The measurements were performed on the Livermore EBIT, which uses a monoenergetic electron beam to excite highly charged ions of choice. Our present investigations focus on the K-shell spectrum of heliumlike Fe^{24+} as well as that of neighboring charge states.

In our measurements, we relied on the use of two analyzing crystals with different lattice spacings to determine the line polarization. This experimental arrangement made use of the polarization sensitivity of different analyzing crystals, which varied as a function of Bragg angle θ_B. With each crystal, the iron K-shell spectrum was recorded in a dispersion plane perpendicular to the beam direction. One crystal analyzed the emission near $\theta_B \approx 45^o$, and an almost pure polarization state parallel to the electron beam axis was reflected. The other crystal analyzed the emission near $\theta_B \approx 28^o$, and a mixture of the polarization states parallel and perpendicular to the beam axis was reflected. Typical results of such measurements are shown in Fig. 1. Very different line ratios were obtained in the two measurements and were used to infer the amount of polarization.

Measurements for different ion species and under different excitation conditions, including dielectronic recombination that produced K-shell emission in Fe^{23+} and Fe^{22+}, have been performed to test theory and develop the use of polarization spectroscopy for diagnostic purposes of electron-ion interactions in high-temperature, non-Maxwellian plasmas.

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References

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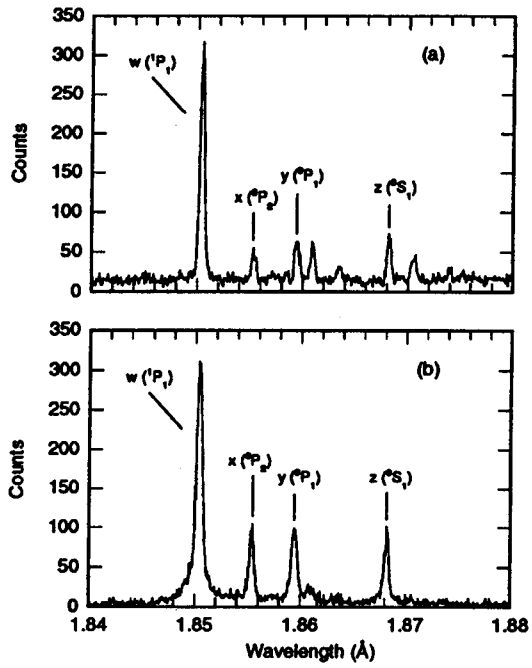

Figure 1: Crystal-spectrometer spectra of the Fe^{24+} lines excited by a 6850-eV electron beam and emanating from upper levels $1s2p\ ^1P_1$, $1s2p\ ^3P_2$, $1s2p\ ^3P_1$, and $1s2p\ ^3S_1$ to the $1s^2\ ^1S_0$ ground state; (a) spectrum obtained with a Quartz(203) crystal at a Bragg angle of 42.5°; (b) spectrum obtained with a LiF(200) crystal at a Bragg angle of 27.5°. Unlabled features are from transitions in Fe^{23+} and Fe^{22+}.